

Quiet Pavement & Noise Research in California

TRB ADC40 July 2005



Bruce Rymer

Paul Donovan

ILLINGWORTH & RODKIN, INC.
/// Acoustics • Air Quality ///

<http://www.dot.ca.gov/hq/env/noise/index.htm>

MAR 10 2003

Presented By:

Bruce Rymer
California Dept. of Transportation
Division of Environmental Analysis
1120 N Street, MS27
Sacramento, CA 95814
Tel: 916/653-6073
E-mail: bruce_rymer@dot.ca.gov

And

Paul Donovan
Illingworth & Rodkin, Inc.
505 Petaluma Blvd. South
Petaluma, CA 94952
Tel: 707/766-7700
E-mail: pdonavan@illingworthrodkin.com



Imperial County, CA 1926

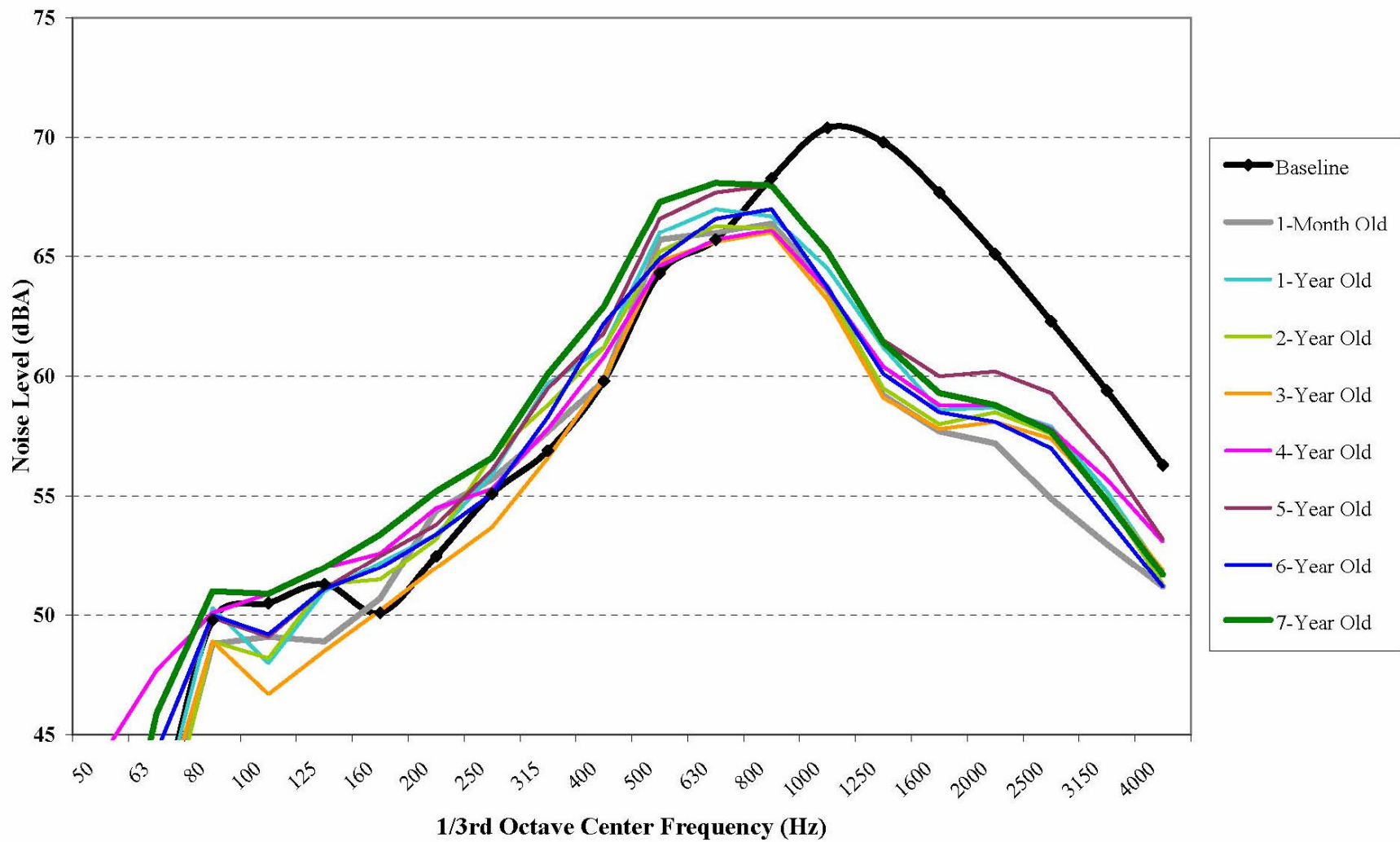
IH-80 at Davis Study

Longest Running Quiet Pavement Study in the Nation

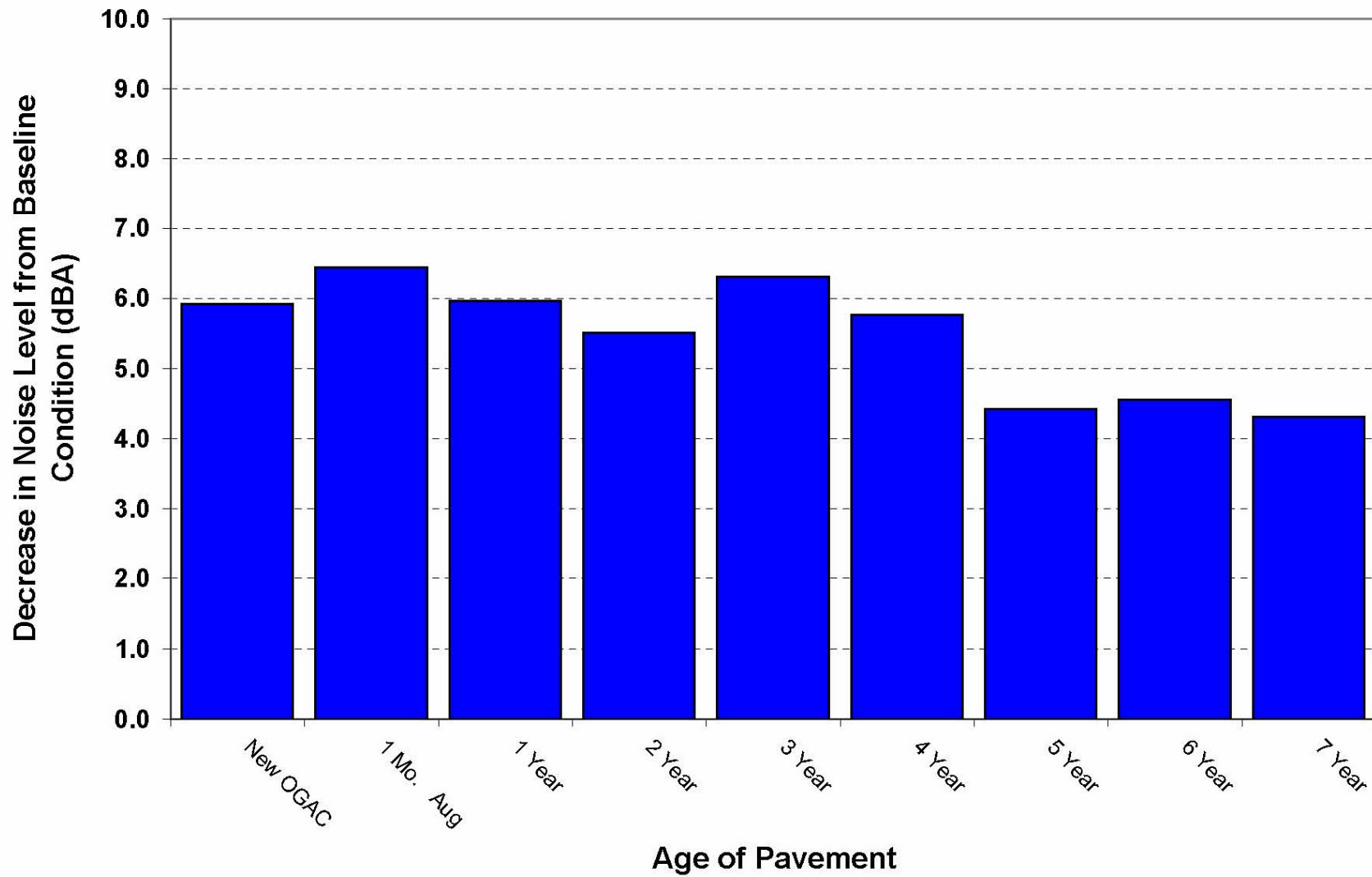


JUN 23 2005

SUMMARY OF WB REF SPECTRA



Calculated Change in Traffic Noise Level - Reference Sites 20m



I-80 DAVIS OGAC AGING STUDY

7th YEAR FINDINGS

At 7 years, the pavement appears to be providing 4.3 dBA reduction when compared with the original AC pavement. The pavement provided about 6 dBA reduction during the first 4 years and has provided a steady ~4.0-4.5 dBA reduction over the last three years

TNM2.1 modeling results are about 5 dBA higher than measured levels at the Reference Position that is 20 meters from the near travel lane and 3 meters above ground – *TNM 2.5 will be evaluated with the current measurement set.*

1/3rd octave band spectra show a consistent signature of OGAC conditions for the 7-year aged pavement. This is not only evident at the reference positions, but for the 145-meter distant positions for 1.5- and 4.5-meters above ground. - *The signature is even evident under the quiet upwind conditions. Please note that spectra are not normalized for the slight differences that may have occurred under different traffic conditions and they are not corrected in magnitude for variations in the strength of the wind field*

Seasonal trend continues to show a general tendency for higher levels in the colder winter months -*Comparisons to original AC are only made for measurements in June when AC baseline levels were measured*

A photograph of a road with a semi-truck and noise measurement equipment. In the foreground, there is a grassy field with a tripod-mounted sensor and an orange equipment case. A semi-truck is driving on the road in the background. The sky is clear and blue.

Contribution of Thin Lift Surface Treatments to the Abatement of Traffic Noise Over A Period of Five Years

LA-138 Project

LA 138 Test Pavements

DGAC



OGAC 75mm



OGAC 30mm



RAC (O)



BWC



Pass By Method

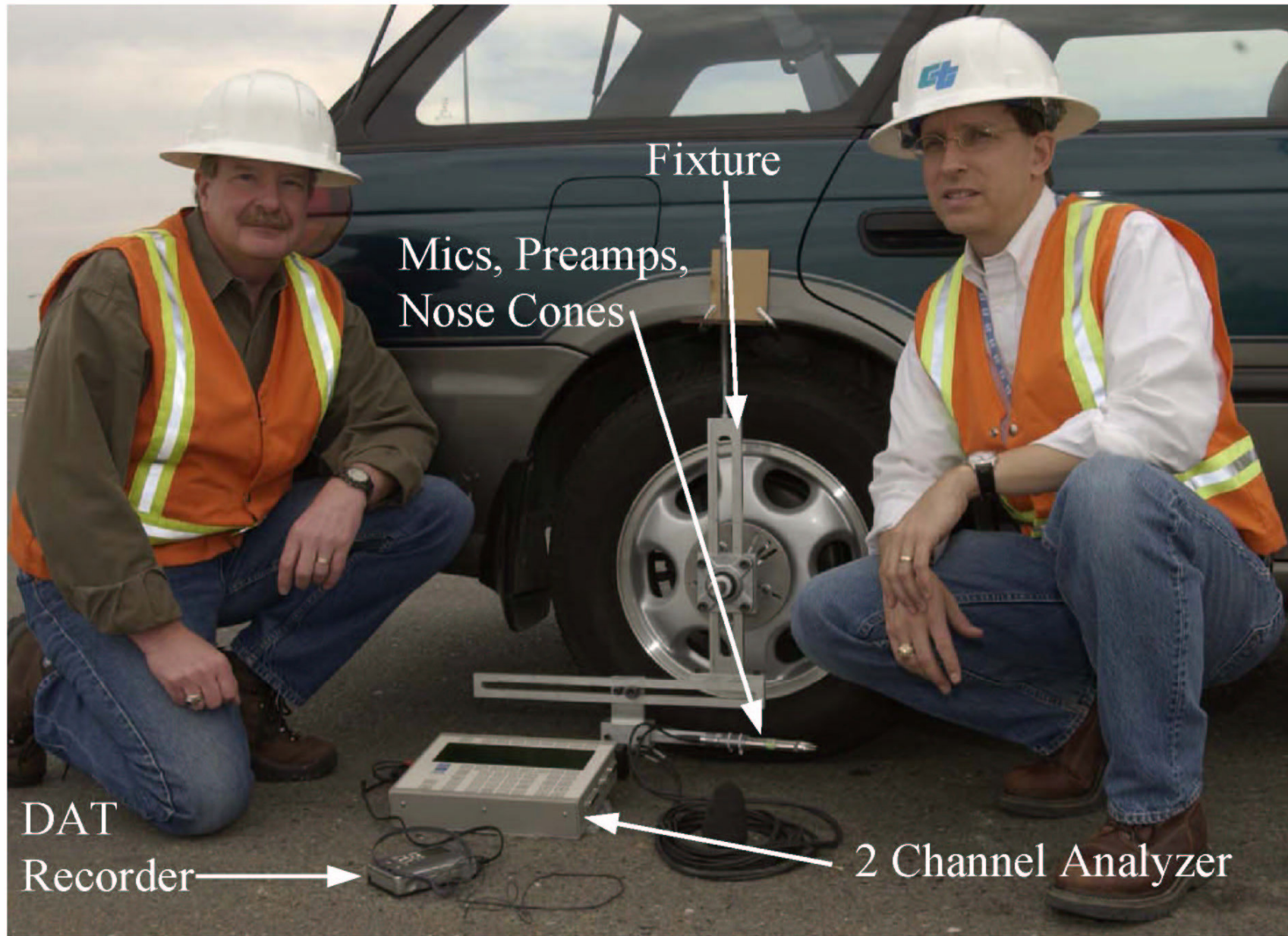


Capture other
data



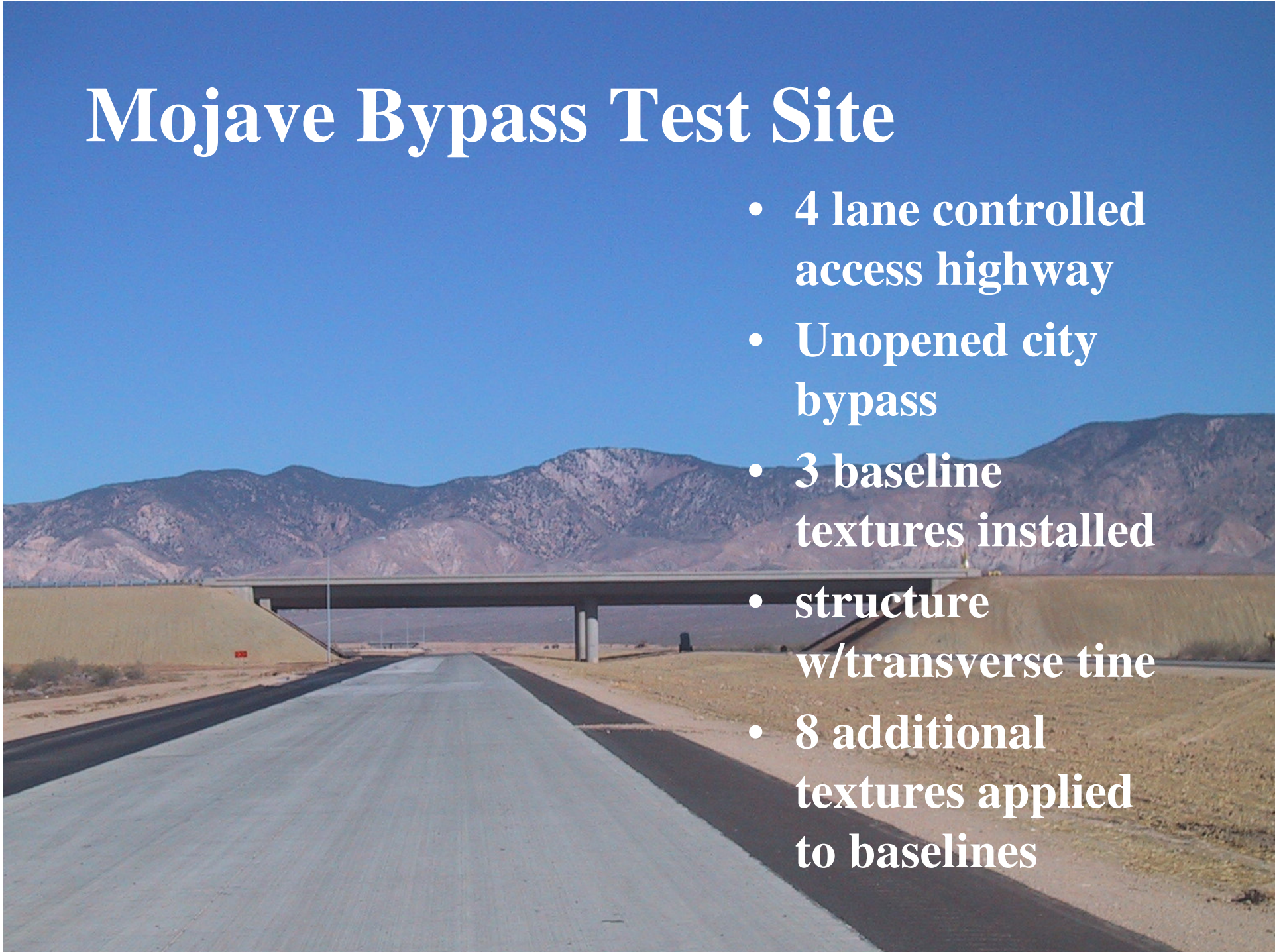
Statistical Pass By (SPB) ISO 11819-1

Sound Intensity Measurement



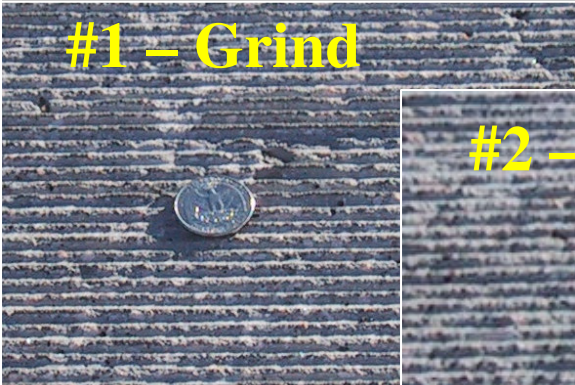
Mojave Bypass Test Site

- 4 lane controlled access highway
- Unopened city bypass
- 3 baseline textures installed
- structure w/transverse tine
- 8 additional textures applied to baselines



Applied Textures to Baseline Surfaces

#1 – Grind



#5 – Grind



#2 – Grind



#8 – Grind



#3 – Groove



#4 – Groove



#7 – Groove



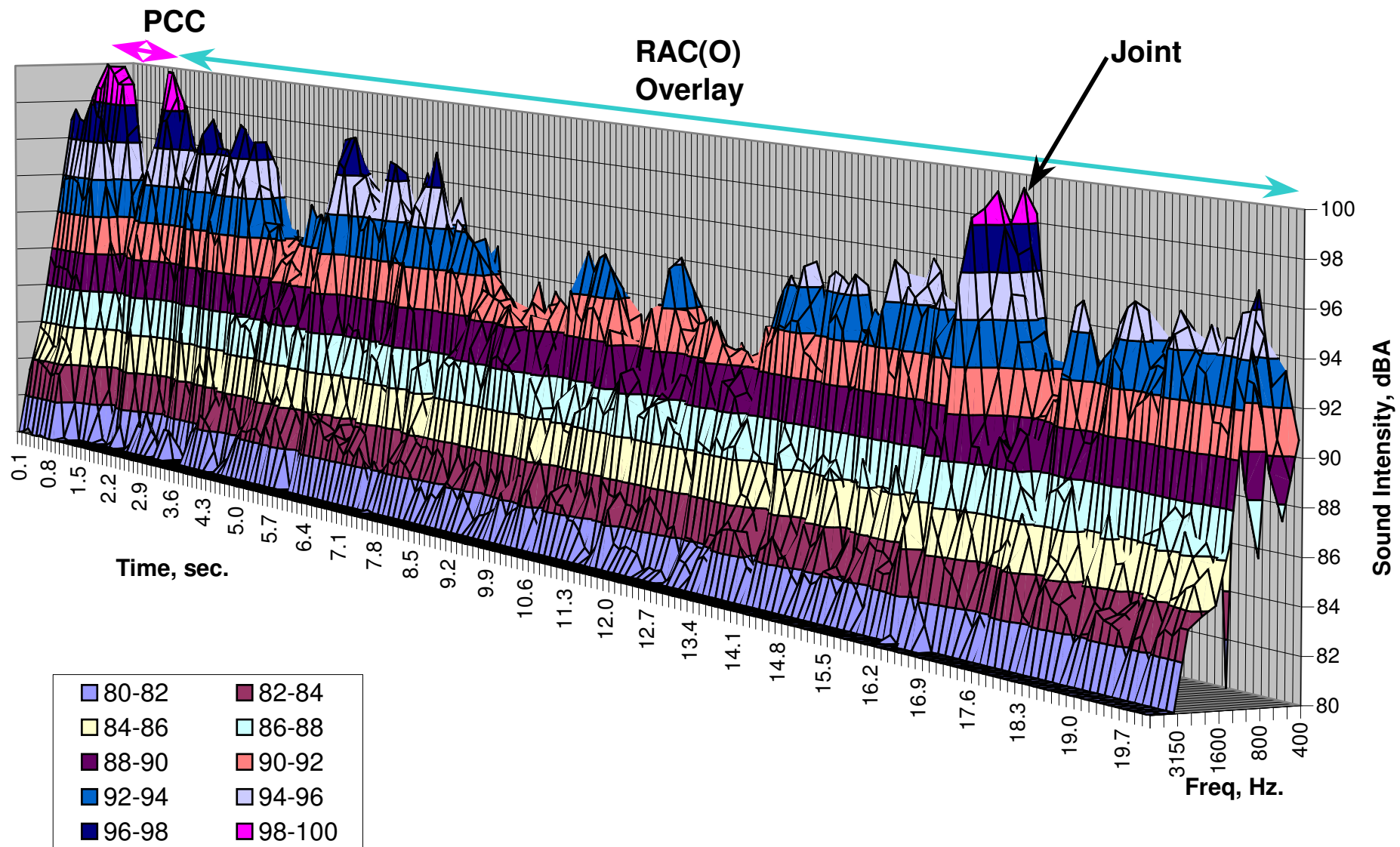
#6 – Groove & Grind



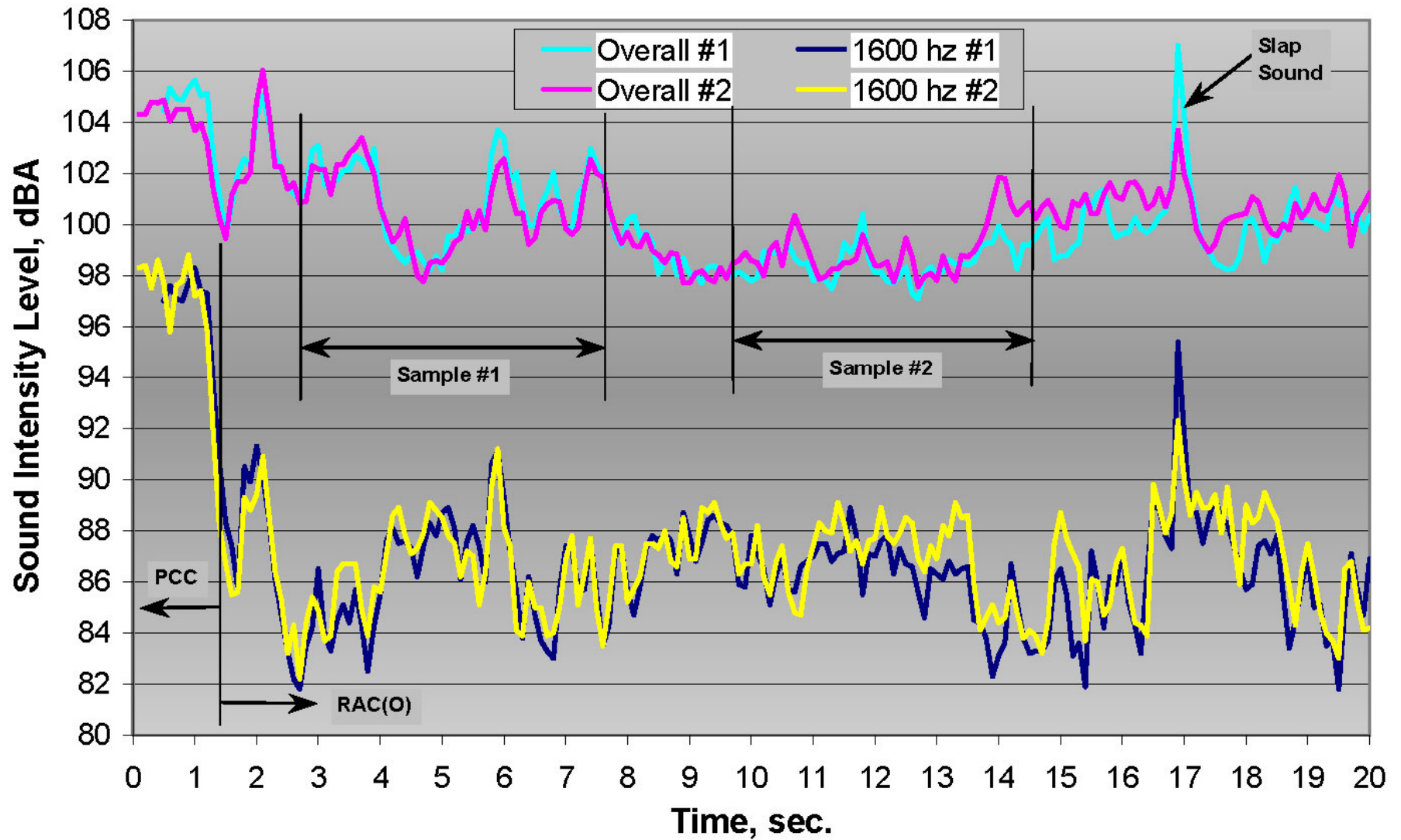
Pavement Rehab Asphalt & Concrete



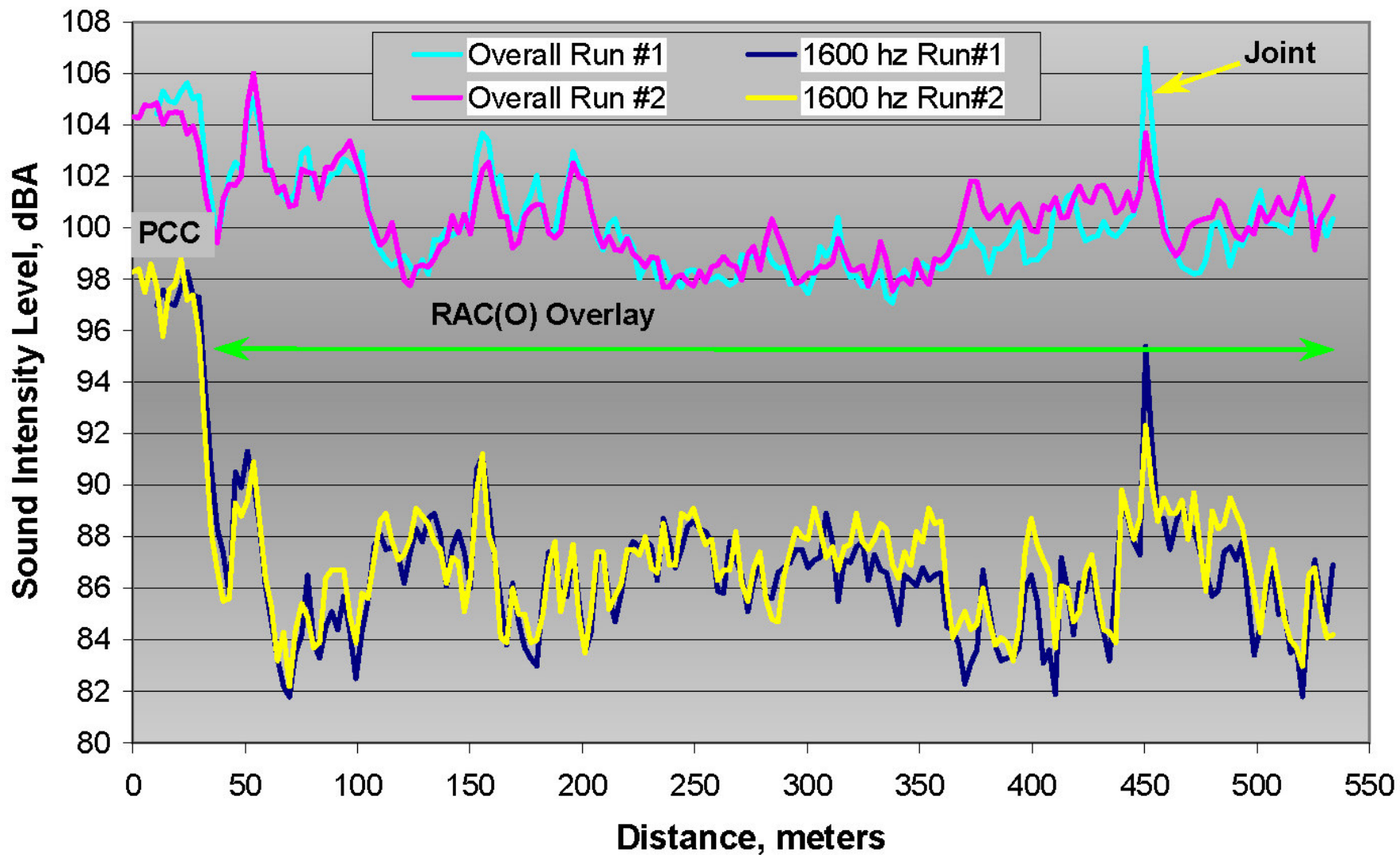
South Bound I-5 Sacramento



Leading Edge of the Tire Contact Patch I-5 Southbound for 2 consecutive Runs

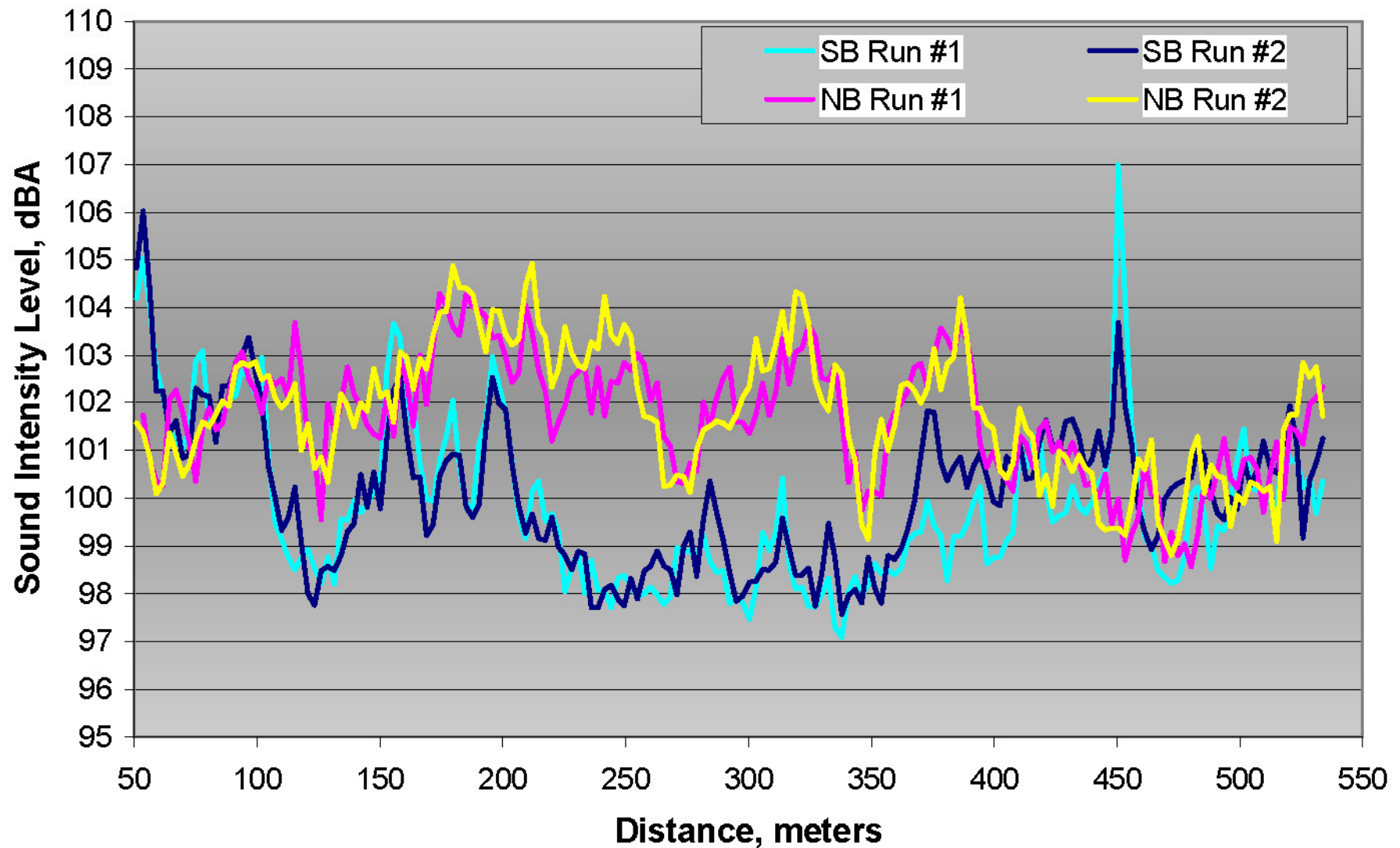


Leading Edge of the Tire Contact Patch I-5 Southbound for 2 consecutive Runs vs Distance



Leading Edge of the Tire Contact Patch

I-5 South & Northbound for 2 consecutive Runs



Bridge Deck & Joint Noise Studies

Location of the
Seismic Joint



Neighbors protest roar of new span

By Lisa Vorderbrueggen

CONTRA COSTA TIMES

Posted Feb 29, 2004

CROCKETT - The honeymoon is over. The bride, as it turns out, snores.

The lovely new \$500 million Carquinez bridge that Crockett welcomed with fireworks and a street fair in November generates a lot more noise than the old one.

State engineers blame its closer proximity, grooved concrete pavement and earthquake safety expansion joints, as well as cars moving faster along the roomier lanes.

The neighbors don't care why. They just want it to stop.

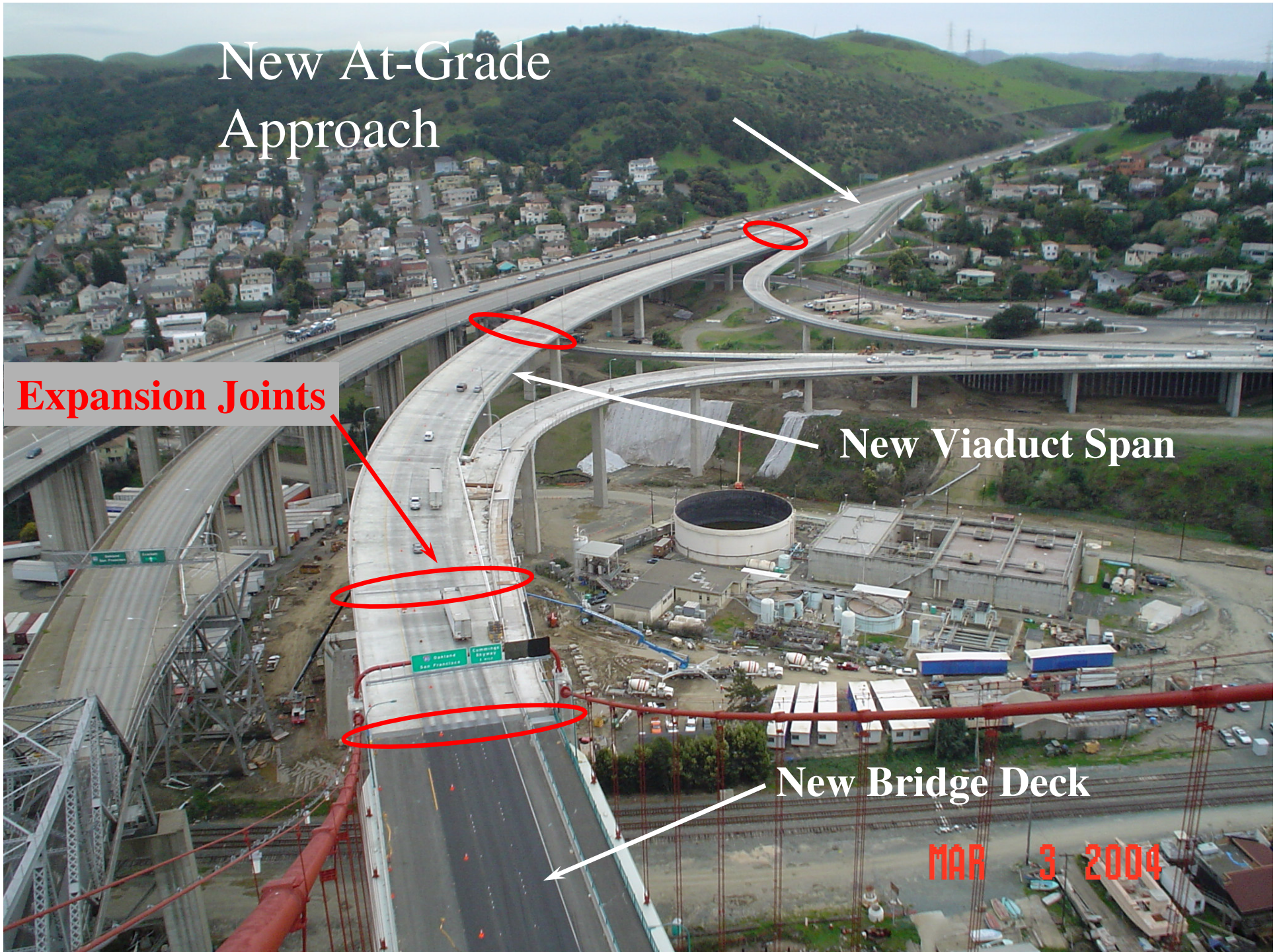
New At-Grade
Approach

Expansion Joints

New Viaduct Span

New Bridge Deck

MAR 3 2004





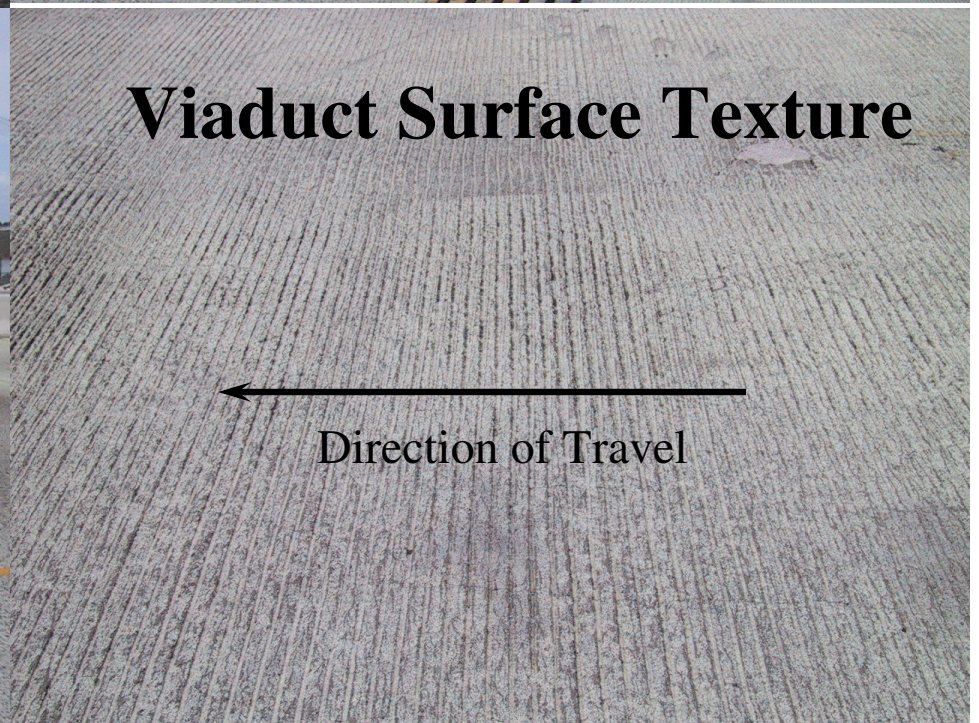
Bridge Joint



Mid Span Joint



End Joint

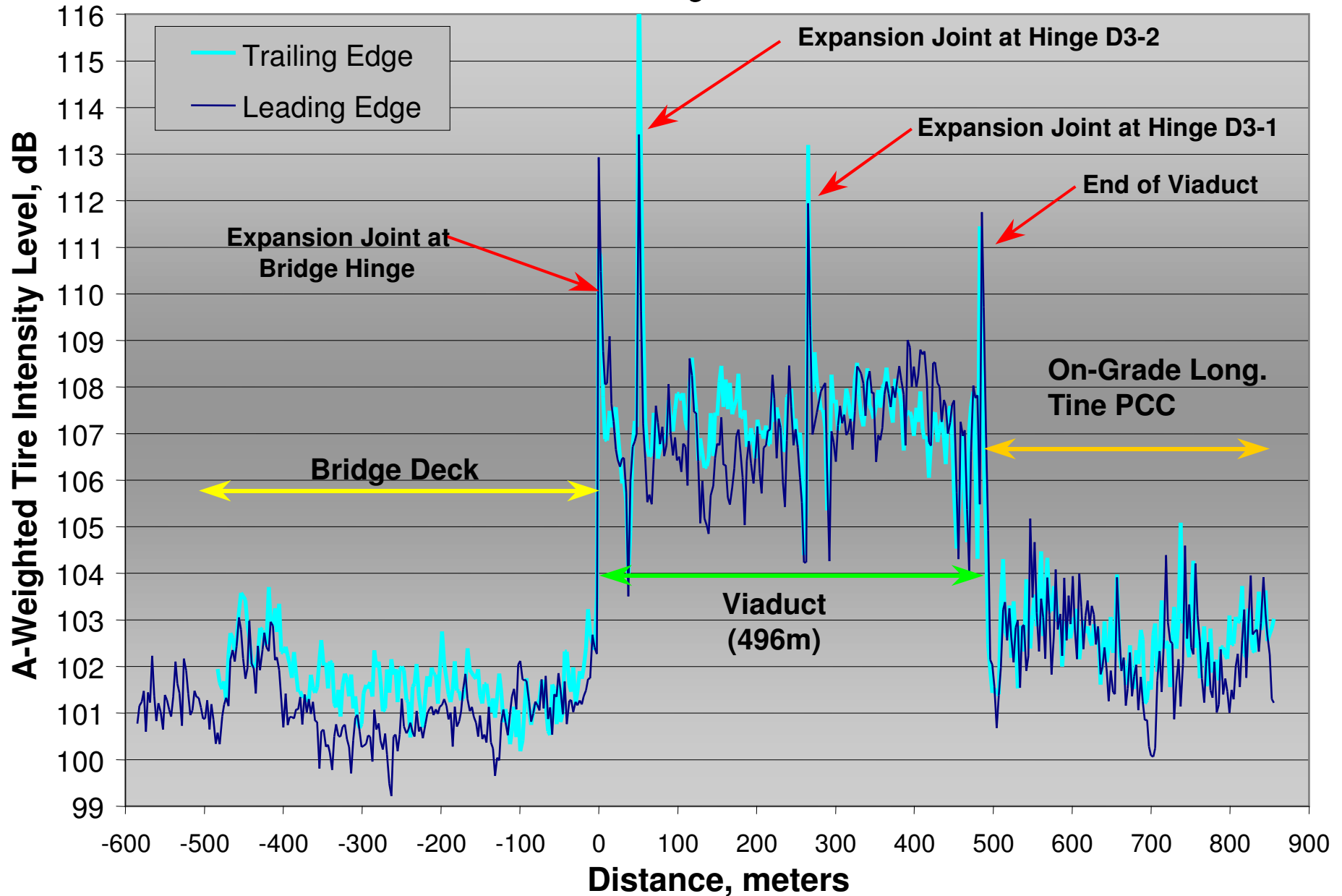


Viaduct Surface Texture

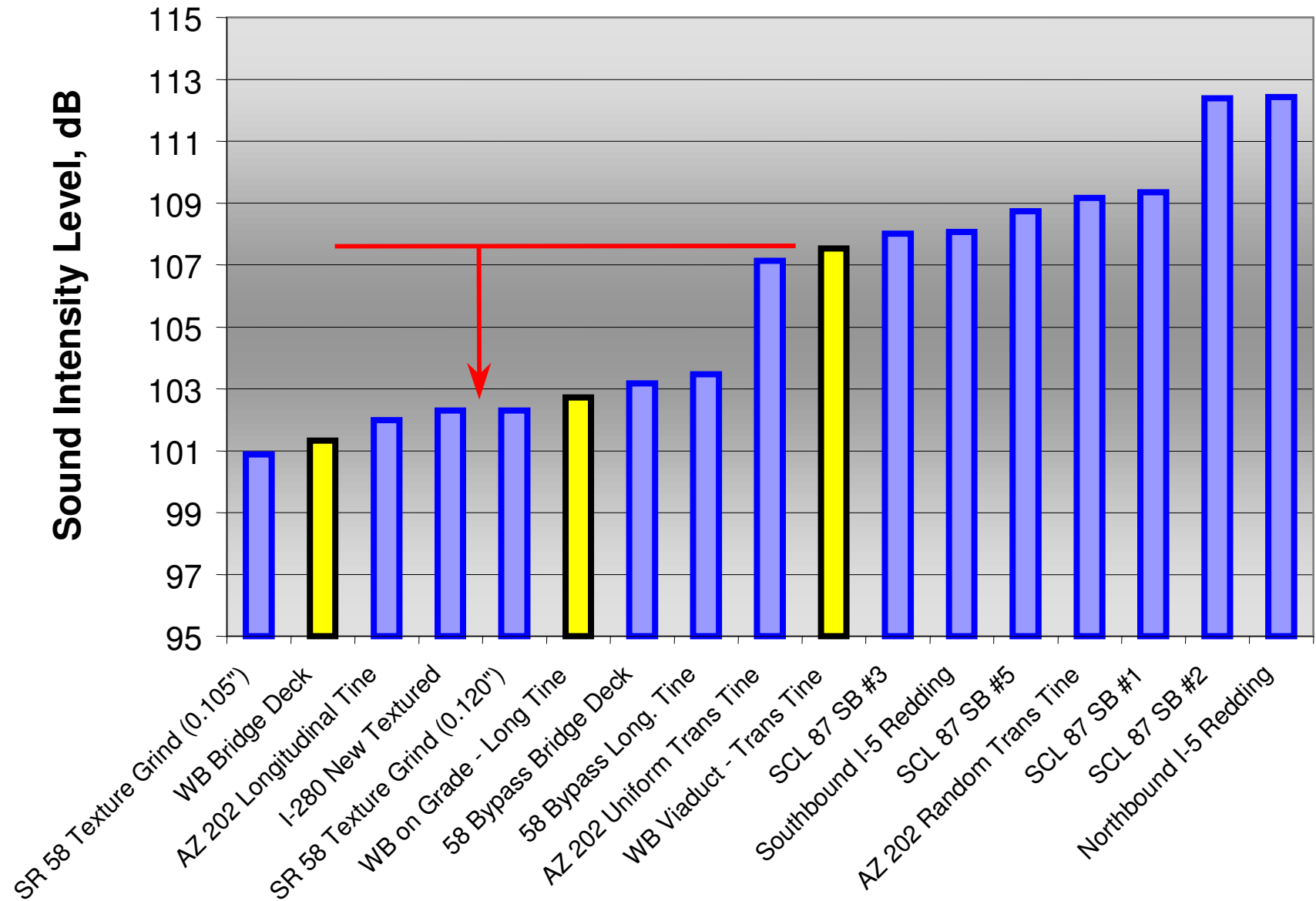


Direction of Travel

Sound Intensity vs. Location



Potential Tire Noise Reduction





**$3\frac{1}{2}$ dB
Reduction**

MAR 16 2004



58 dB - 3dB Reduction

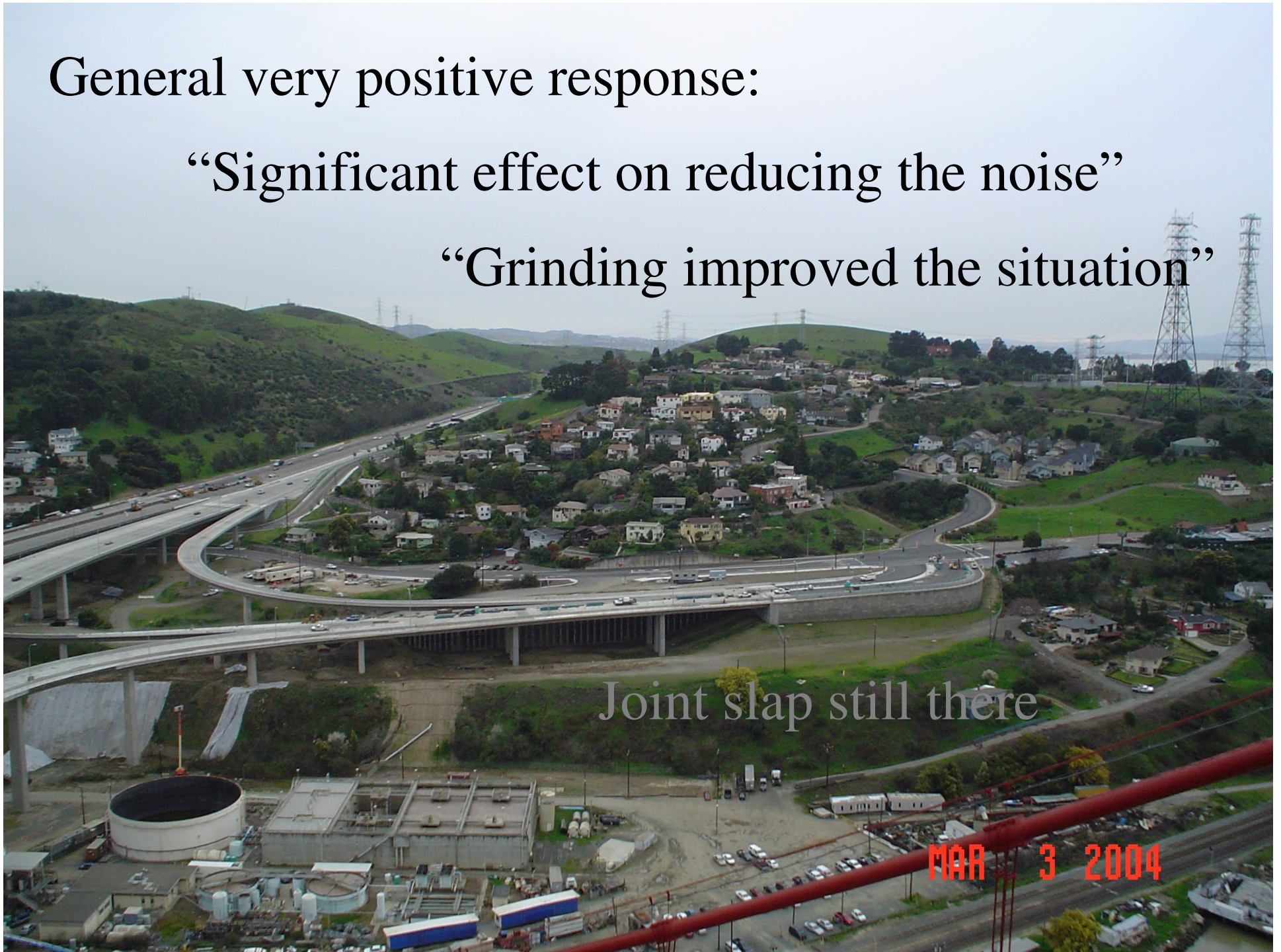
General very positive response:

“Significant effect on reducing the noise”

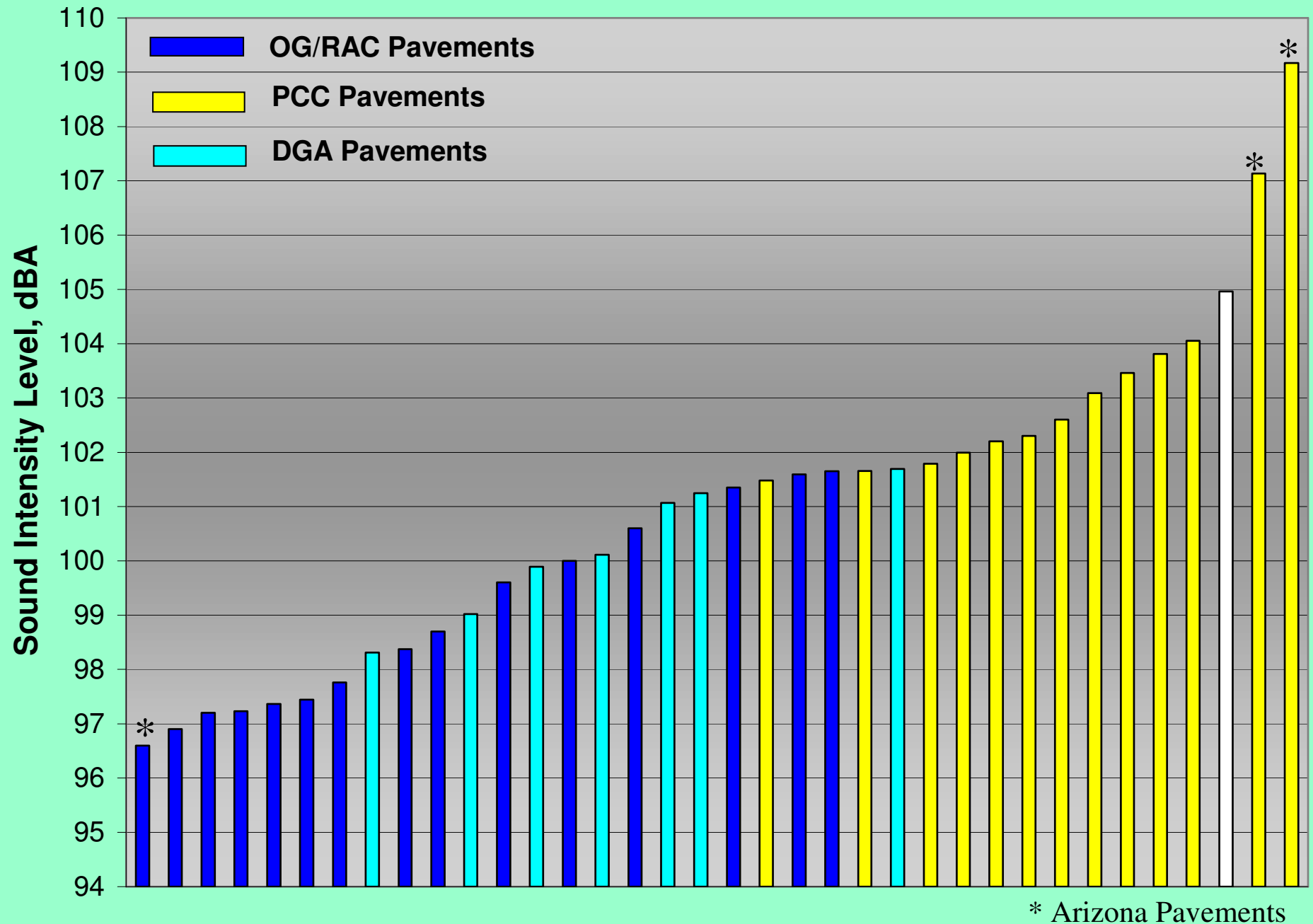
“Grinding improved the situation”

Joint slap still there

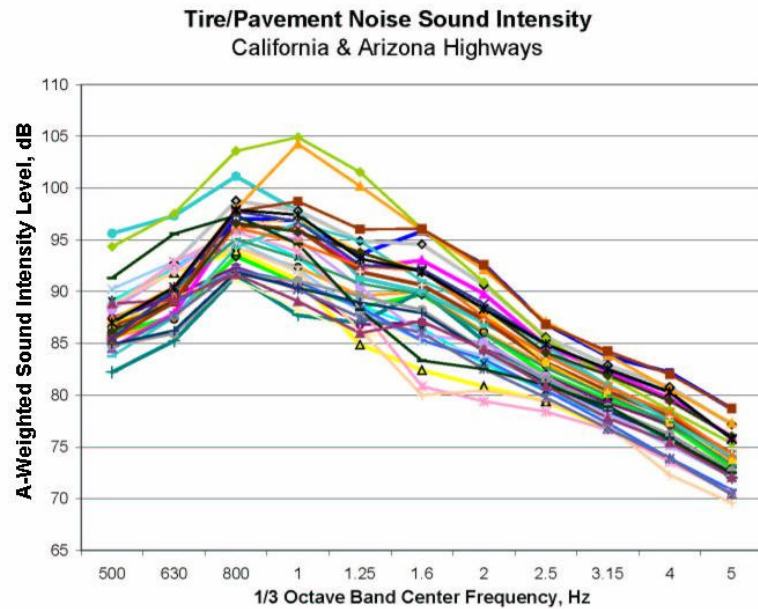
MAR 3 2004



Caltrans State-Wide Data Base



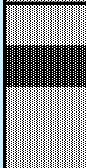
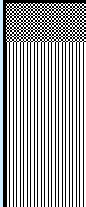
Pavement Noise Index



AC or PCC	State - County - Route - Material - Description	Pavement/Tire Sound Intensity	Noise Level at 50 Feet ** (Sound Pressure Level)
		(Avg dBA)	(dBA)
	AZ Marc 10 ARFC	96.6	67
	CA Sac Test Track DGAC	96.7	67
	CA SM 280 OGAC SB Shoulder	96.8	67
	CA LA 138 OGAC 75 mm	96.9	67
	CA SM 280 RAC(Type O)	97.2	67
	CA LA 138 RAC(Type O)	97.2	67
	AZ Marc 202 ARFC Best Condition	97.4	67
	CA LA 138 OGAC 30mm	97.4	67
	CA Fre 5 RAC(Type O) High Binder	97.8	68
	CA LA 138 DGAC	98.3	68
	CA SBd 40 RAC(Type O) High Binder	98.4	68
	AZ Marc 10 P-ACFC	98.7	69
	CA LA 138 DGAC Existing	99.0	69
	AZ Marc 10 SMA Stone Matrix Asphalt	99.6	70
	CA LA 138 BWC New	99.9	70
	AZ Marc 10 ARFC	100.0	70
	CA SBd 40 DGAC Exist	100.1	70
	AZ Marc 10 Permeable European Mix. OG	100.6	71
	CA LA 138 DGAC Reference Section	101.1	71
	CA SM 280 PCC Ground	101.2	71
	AZ Marc 202 ARFC Poor Condition	101.4	71
	CA Ker 58 PCC New Burlap Longitudinal	101.5	71
	CA Yub 70 OGAC Aged	101.6	72
	CA Yol 80 OGAC	101.7	72
	CA SCI 85 PCC New Longitudinal Tine	101.7	72
	CA Sol 80 DGAC	101.7	72
	CA Ker 58 PCC New Broom Longitudinal	101.8	72
	AZ Marc 202 PCCP Longitudinal Tine	102.0	72
	CA Sac 5 PCC Aged Longitudinal Tine	102.2	72
	CA SM 280 PCC Texture Grind (var. 8mm/0.1km)	102.3	72
	CA Sha 5 PCC NB Bridge Deck Longitudinal Grind	102.3	72
	CA SM 280 PCC Grind (var. 19mm/0.1km)	102.6	73
	CA LA 14 PCC Fair Condition Longitudinal Tine	103.1	73
	CA Ker 58 PCC New Longitudinal Tine	103.5	73
	CA SM 280 PCC Aged Longitudinal Tine	103.8	74
	CA Sol 80 PCC Aged Longitudinal Tine	104.1	74
	CA SM 84 Chip Seal New	105.0	75
	AZ Marc 202 PCCP New Tranverse Tine	107.1	77
	CA Sha 5 PCC SB Bridge Deck Trans. Astroturf (Aged)	108.1	78
	AZ Marc 202 PCCP New Random Tranverse Tine	109.2	79
	CA Sha 5 PCC NB Bridge Deck Trans. Astroturf (New)	112.4	82

Pavement Noise Index

2004 Pavement Noise Level Index*

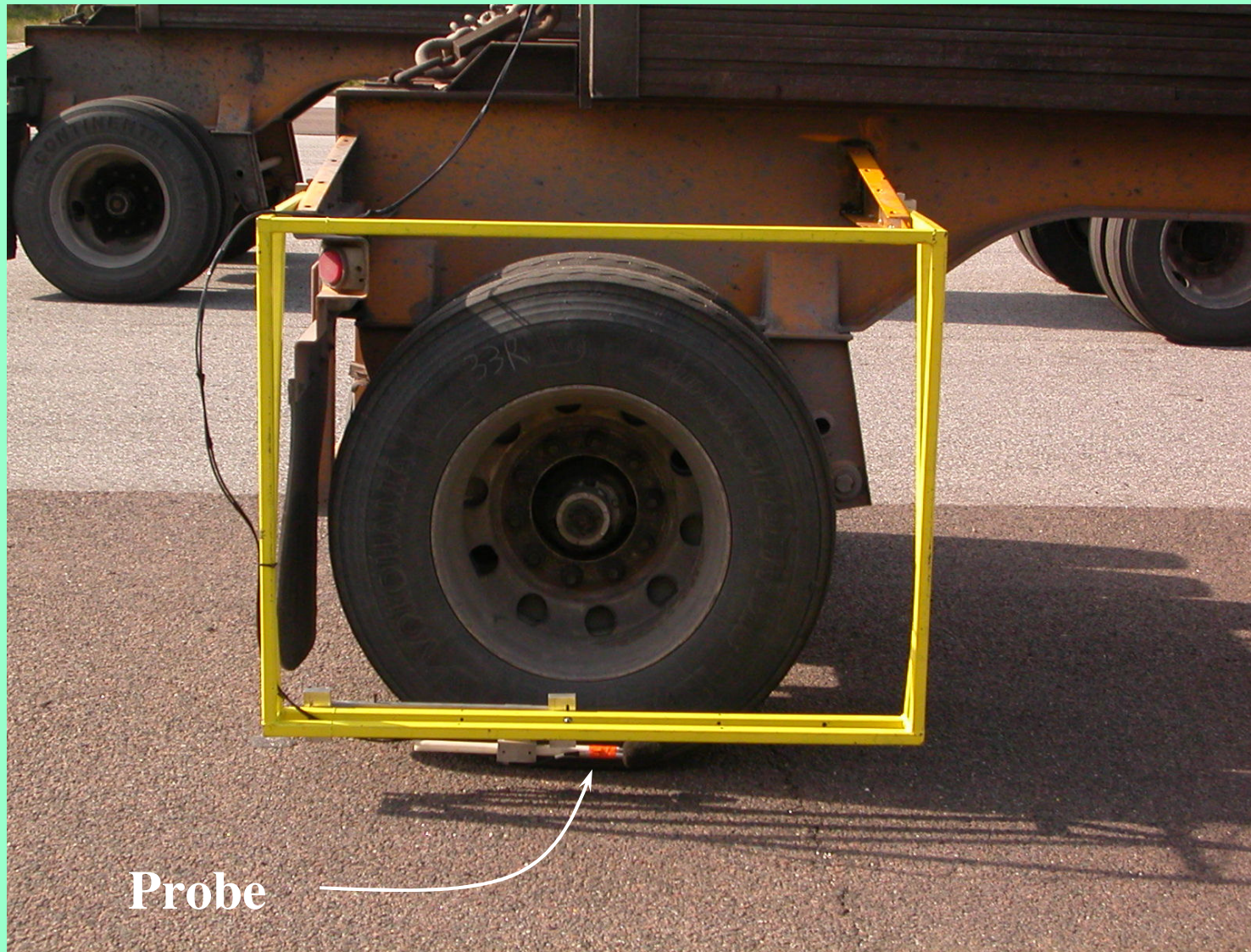
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	AZ Marc 10 ARFC	96.6	67
	CA Sac Test Track DGAC	96.7	67
	CA SM 280 OGAC SB Shoulder	96.8	67
	CA LA 138 OGAC 75 mm	96.9	67
	Omitted for this slide		
	CA SM 84 Chip Seal New	105.0	75
	AZ Marc 202 PCCP New Transverse Tine	107.1	77
	CA Sha 5 PCC SB Bridge Deck Trans. Astroturf (Aged)	108.1	78
	AZ Marc 202 PCCP New Random Transverse Tine	109.2	79
	CA Sha 5 PCC NB Bridge Deck Trans. Astroturf (New)	112.4	82

Tire/Pavement Noise Intensity Testing in Europe

*A Report of the
NITE Project*



Truck Tire/Pavement Noise Measurements



Probe

Localizing Truck Noise Sources or Noise Mapping



- **Improve Traffic Noise Model**
- **Determine Quiet Pavement impact on heavy truck noise levels**
- **Improve roadside design of noise mitigation features**

AASHTO/FHWA Develop Specification -Standard Practice for Measurement of Tire-Pavement Noise Using the On- Board Sound Intensity Method

Sound Intensity
Vector

$$\vec{I} = p\vec{U}$$

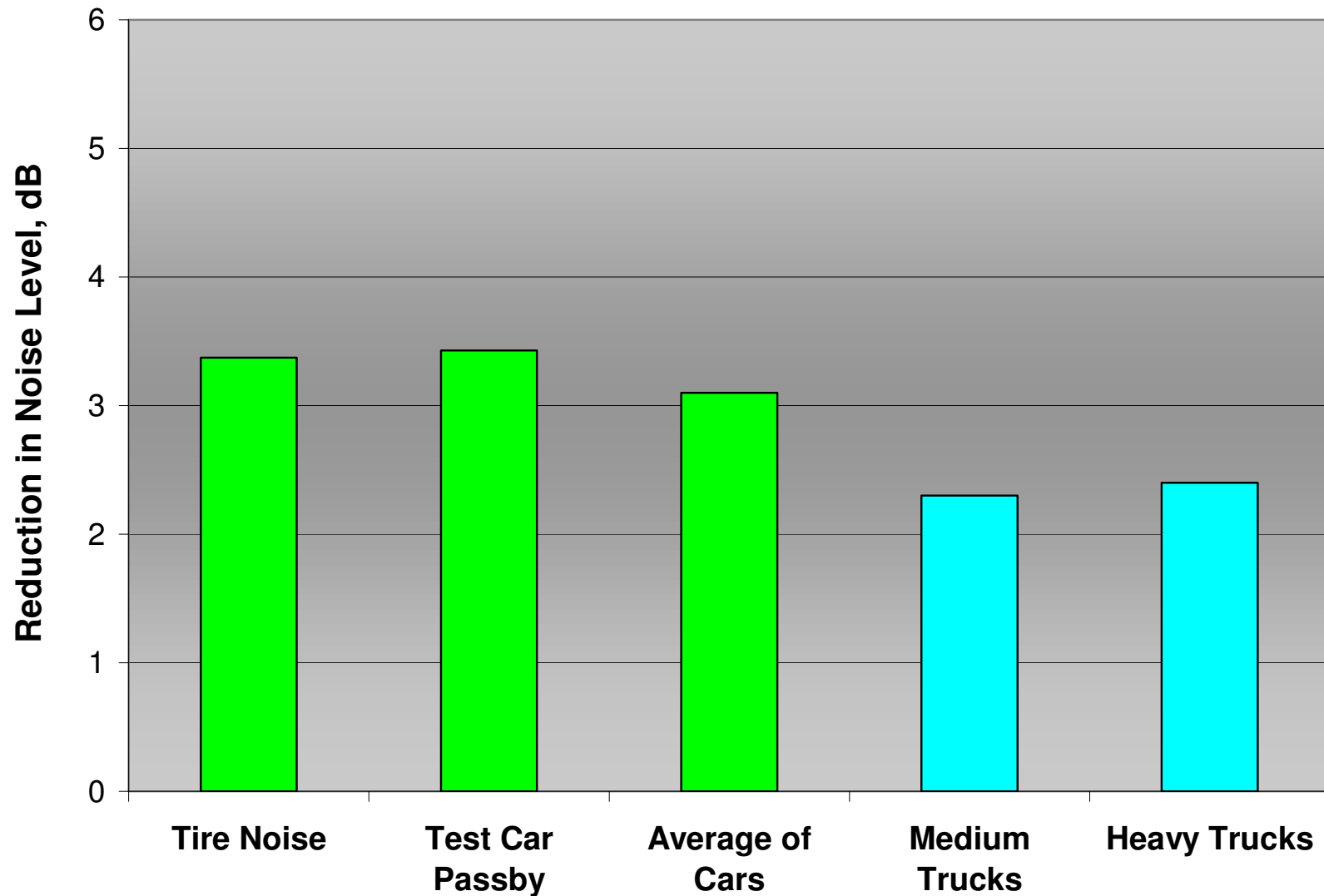




Localizing Truck Noise Sources



Truck Noise Reduced Less by Pavement Changes

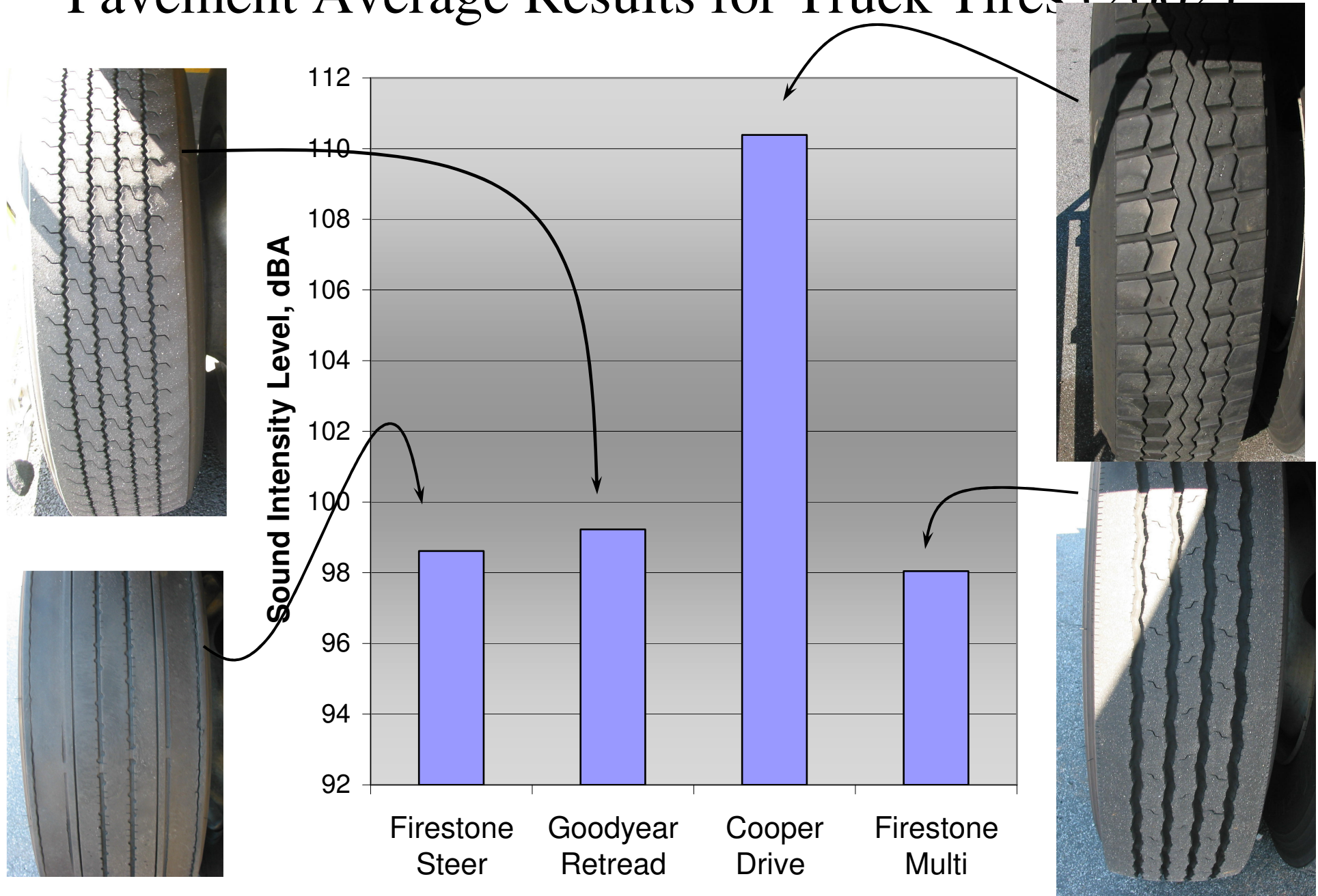


Truck Noise Reduced Less by Pavement Changes

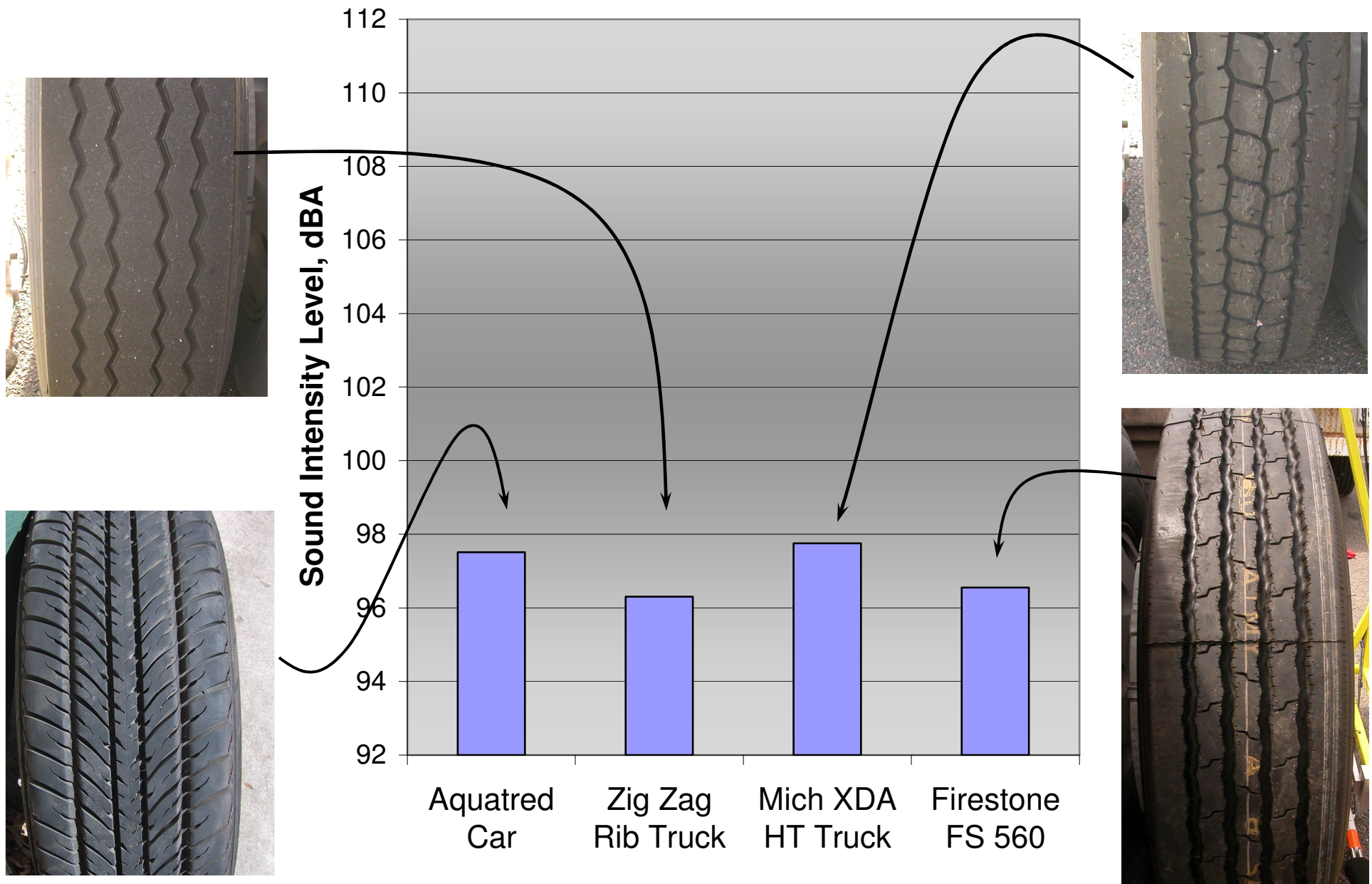
Possible Reasons:

- Truck tires behave differently than passenger car tires
- Contribution of noise sources different for cars & trucks

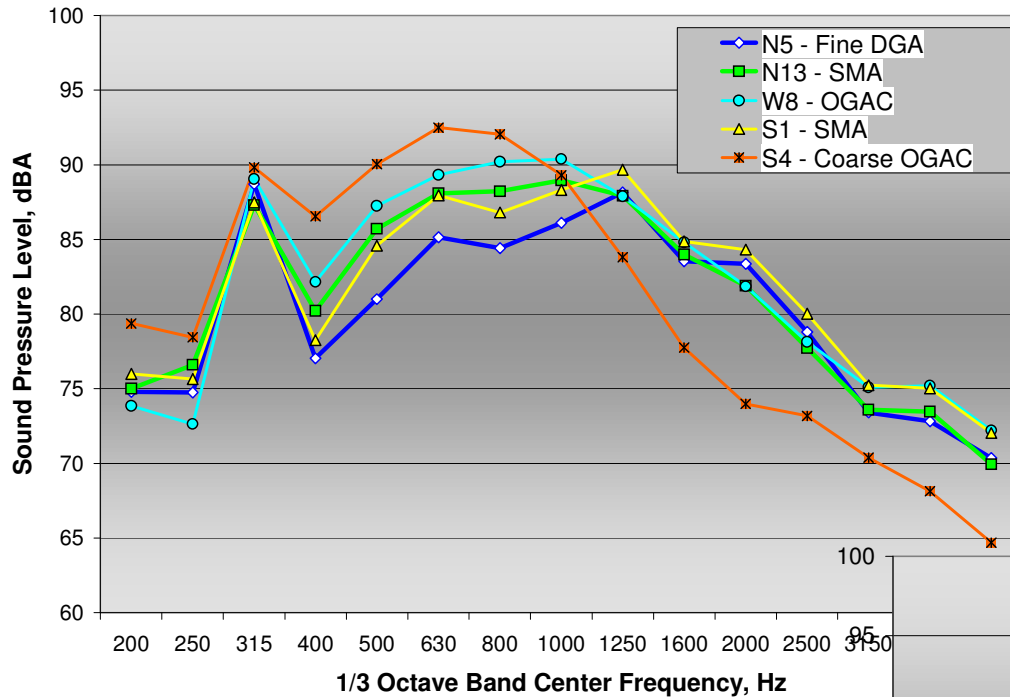
Pavement Average Results for Truck Tires (2002)



4 Pavement Averages for Truck & Car Tires (2005)

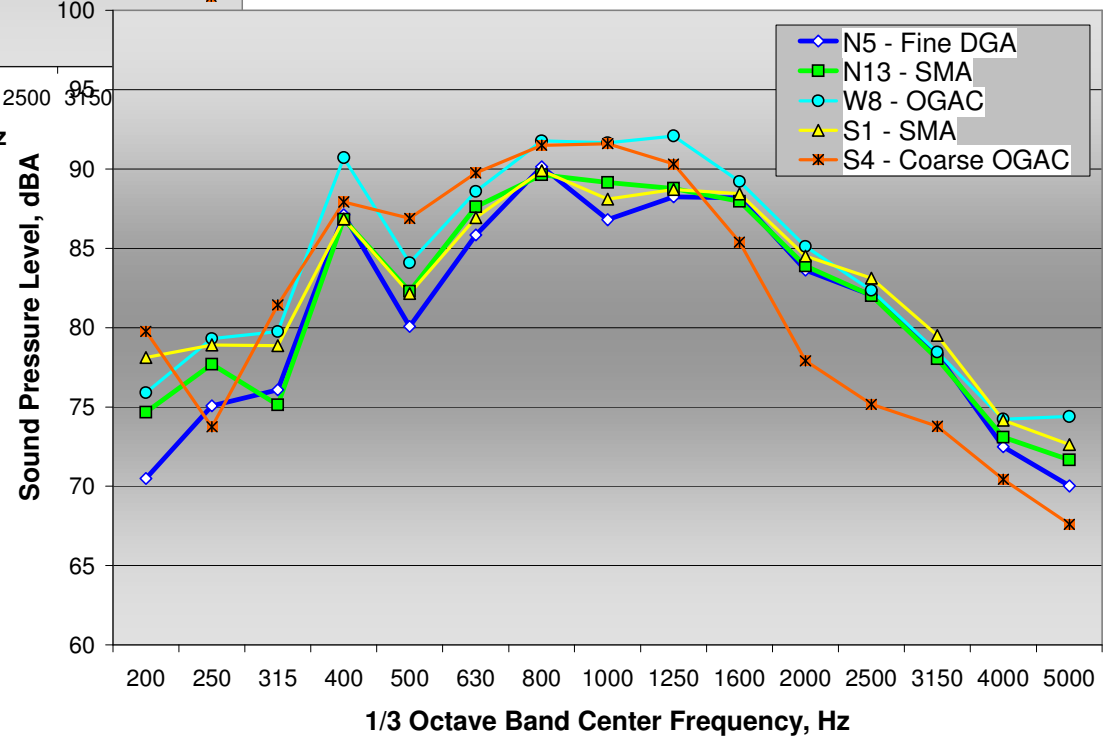


Zig Zag Rib & XDA HT Truck Tires



Zig-Zag 5 Rib Tire

Cooper Drive Axle Tire



Summary

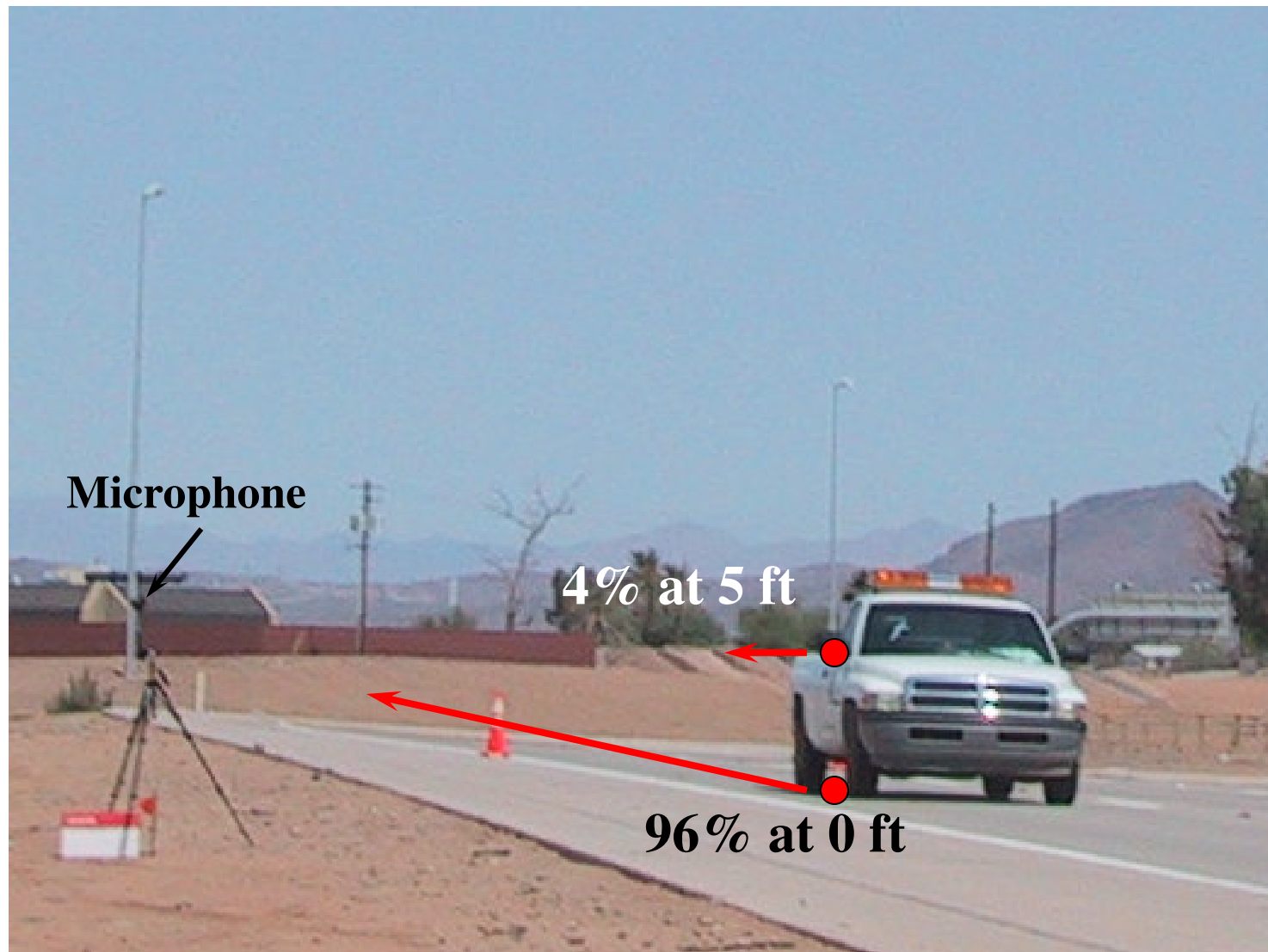
- Significant difference in truck tire/pavement noise depending on tire design
- Initial indication that larger element tread designs maybe less sensitive to pavement differences
- Further work:
 - Analyze 2005 results for wider range of pavement types
 - Additional tests with more aggressive tread designs
 - Determine if relative noise performance of pavements depends on truck tire design parameters

Truck Noise Reduced Less by Pavement Changes

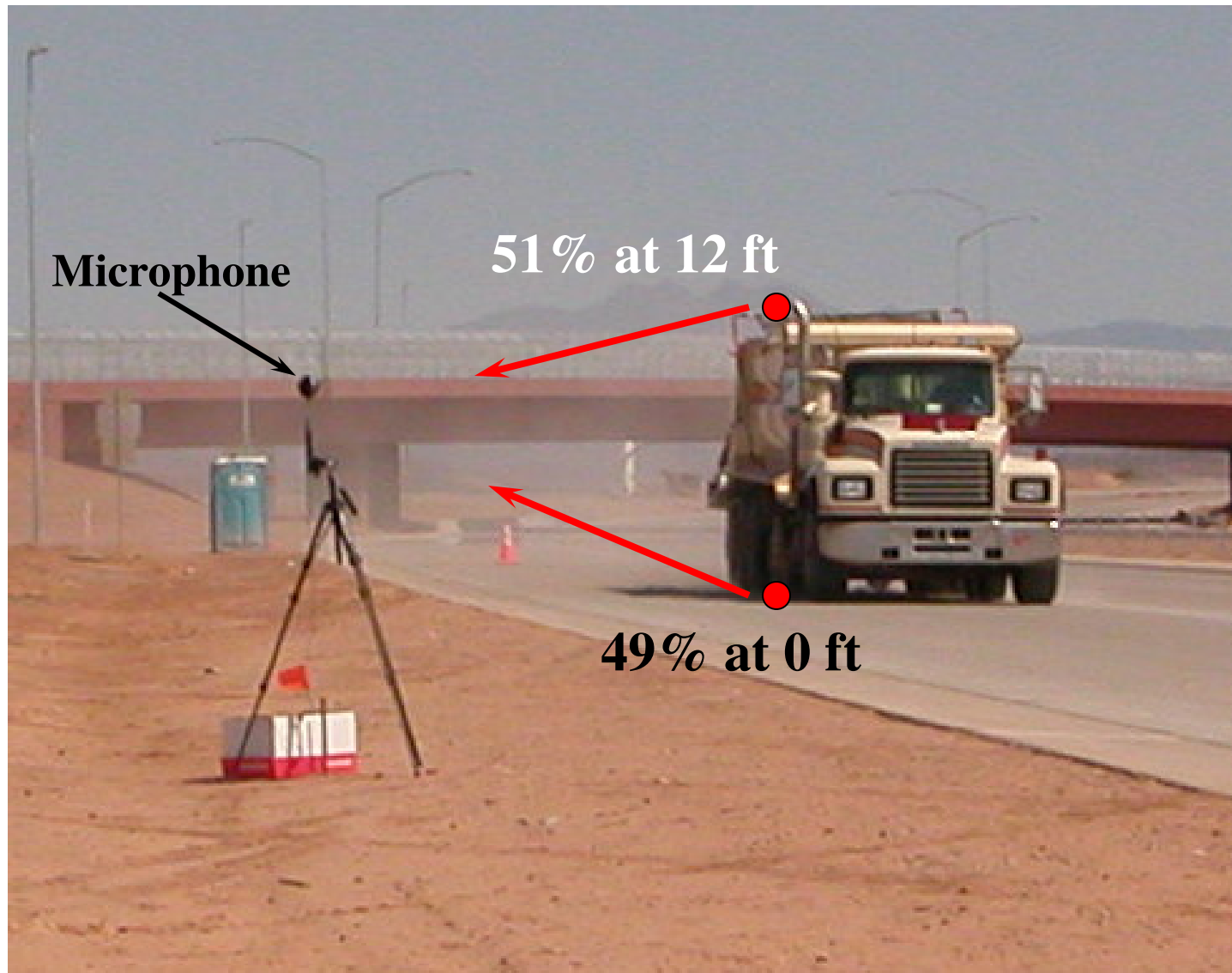
Possible Reasons:

- Truck tires behave differently than passenger car tires
- Contribution of noise sources different for cars & trucks

Light Vehicle Source Height – FHWA Distribution



Truck Source Height – FHWA Distribution



Truck Noise Source Localization Project

Concept

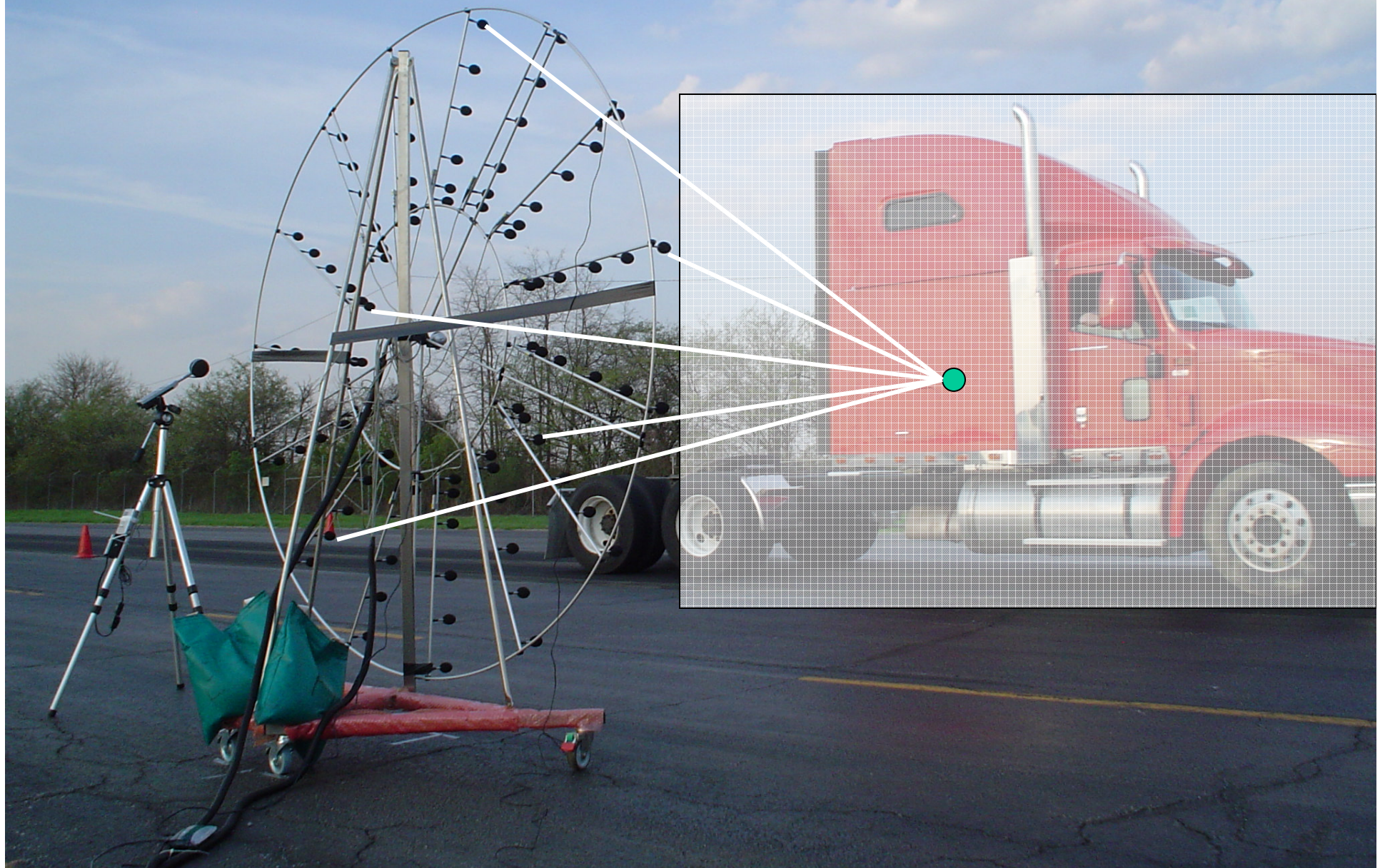
- Apply latest technology to obtain “acoustic pictures” of truck noise sources
- Deploy acoustic array to measure passing trucks

Approach

- Initial technology demonstration project
- Later expand to actual roadway and more cases



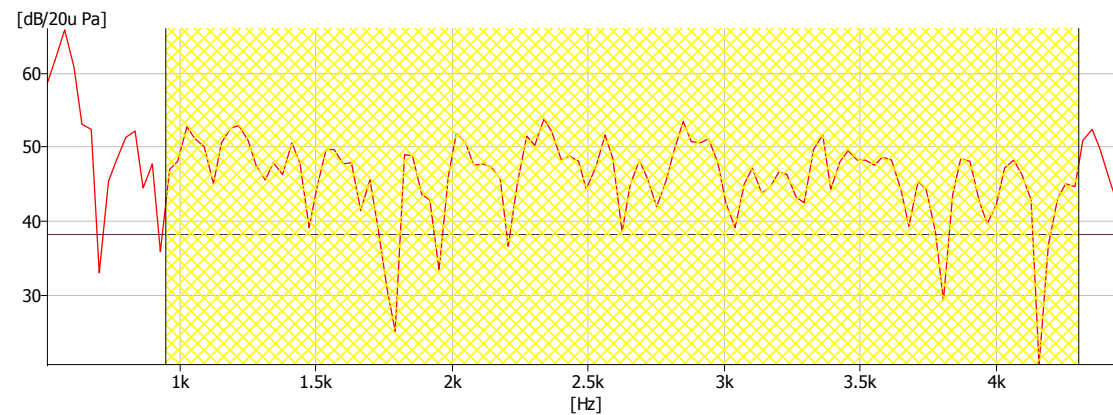
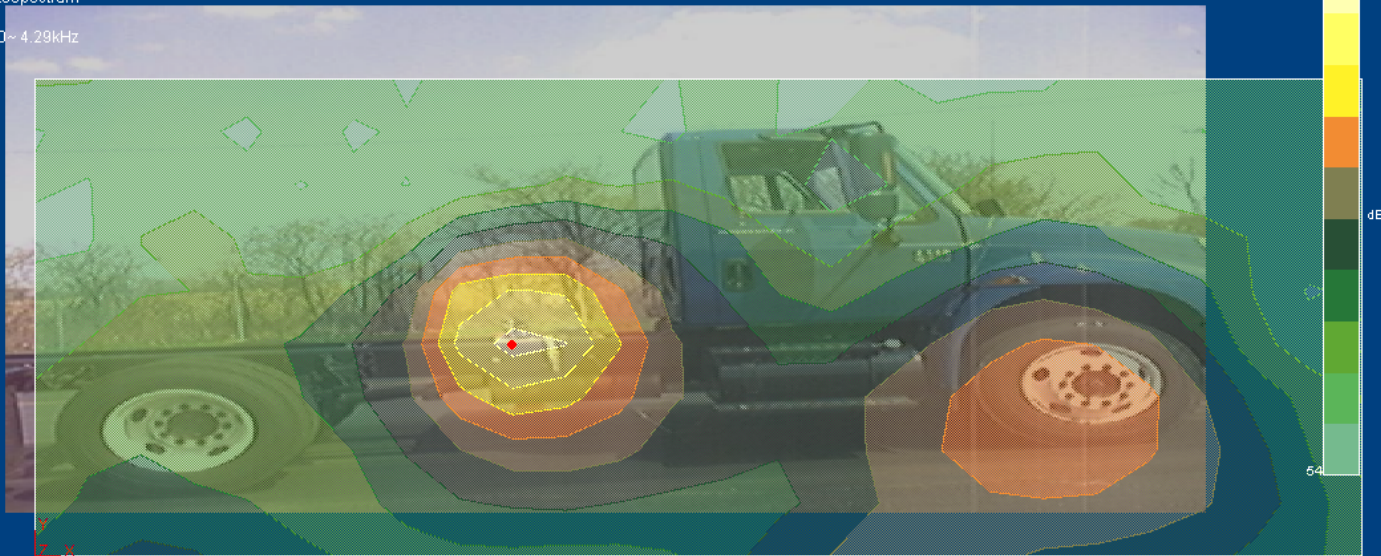
Beamforming Applied to Trucks



Navit 4300, 50 MPH w/speaker - Stat, 512.0-4480.0Hz

Autospectrum

960~ 4.29kHz



Cursor values
X: 4.48k Hz
Y: 38.33 dB/20u Pa
Delta Cursor
Start :944 Hz
Stop :4.3k Hz
Centre :2.62k Hz
Width :3.36k Hz